MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXXXI. MAY 13, 1921. No. 7

Professor A. S. EDDINGTON, F.R.S., PRESIDENT, in the Chair.

Patrick Y. Alexander, 3 Whitehall Court, London, S.W. 1;
Donald Luther Edwards, A.R.C.S., D.I.C., 34 Lymebourne Avenue, Sidmouth, Devon;
Frederick Herbert Howard, M.A. Camb., Head Master, L.C.C. "Hugh Myddelton" Junior School, Clerkenwell, E.C. 1, 15 Dungarvan Avenue, Putney, S.W. 15;
Mrs. Mary E. Merton, Slopes, Woldingham, Surrey; and
The Rev. John Pierce Price, Bryn-Wynno, Porth, Rhondda, South Wales,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Miss Beatrice Mary Cave-Browne-Cave, M.A., Director of Mathematical Studies, Girton College, Cambridge (proposed by J. W. Nicholson);
William Michael Herbert Greaves, B.A., Smith's Prizeman, St. John's College, Cambridge (proposed by A. S. Eddington);
Richard Griffith Quirk, Principal of the Dublin School of Navigation and Seamanship, 4 Eglinton Park and 23 Eden Quay, Dublin (proposed by M. H. Clarke); and
John Whitridge Wilson, 87 Woodvale, Forest Hill, London, S.E. 23 (proposed by W. H. Steavenson).

Fifty-nine presents were announced as having been received since the last meeting, including, amongst others:

Cordoba, Observatorio Nacional Argentino, Catalogue of Zones $-22°$ to $-27°$.

Magnitude Curves of Three Short-Period Variable Stars: RR Leonis, Y Aurigæ, and UU Cassiopeiæ. By C. Martin and H. C. Plummer.

RR Leonis.

1. The variability of RR Leonis was discovered by Miss Leavitt* in 1907 in the course of an examination of plates of the Harvard Map of the Sky. Its provisional number was 170·1907, and other designations are B.D.+24°·2183 and No. 100224 on the Harvard system. A range between mags. 9·0 and 9·8 was indicated in the announcement. The first observations by Luizet † suggested a period between four and five days, but later observations ‡ led him to reduce the first estimate to less than a tenth, with a range of one magnitude, thus making RR Leonis a typical member of the merihemeral class.

2. The elements given by Luizet for maximum are

J.D. 2418 120·357+0·452368 E.

A maximum has been inferred from the present photographic observations at a date following this epoch by 3894·021 days. It is to be supposed that 8608 periods have intervened. Hence the elements now adopted are

J.D. 2422 014·378+0·452372 E,

which differ little from the preceding and appear to suit the Dunsink observations, extending over more than two years, quite well.

3. Information relating to the comparison stars is given in Table I. The magnitudes m_1, m_2 are based on Schwarzschild's

TABLE I.

Star.	Pl. 2061. m_1.	Pl. 2063. m_2.	Mean. m.	Corr.	Final. m'.	P.E.	Range.
B.D.+24°·2182	9·70	9·60	9·65	−·010	9·64	±·020	·12
2179	10·05	9·95	10·00	+·004	10·00	±·013	·09
2181	10·13	10·01	10·07	−·006	10·06	±·016	·10
2184	10·35	10·24	10·30	+·027	10·33	±·016	·10
Oxf. ph.+25°·36561	10·87	10·82	10·85	−·013	10·84	±·016	·08

system for the χ Persei cluster, through two plates exposed at the same altitude to this region and the region of RR Leonis. The mean magnitudes m have been adopted in the reduction of the variable, the plate residuals giving small mean corrections which are incorporated in m', but not used. From the same residuals, of which the extreme range is given in the last column, the probable error for a single plate is inferred and shown in the preceding column.

* *H.C.O. Circular*, 133; *A.N.*, 4218.
† *A.N.*, 4348. ‡ *A.N.*, 4532.

4. The results from 42 exposures on the variable RR Leonis are given in Table II. In the second and third columns are recorded the astronomical date and G.M.T., together with the Julian day and decimal fraction, corresponding to the middle of each exposure, the length of which is shown in the fifth column. The phase in days, given in the fourth column, is reckoned from the preceding maximum according to the elements adopted in § 2. The sixth column gives the deduced photographic magnitude of RR Leonis.

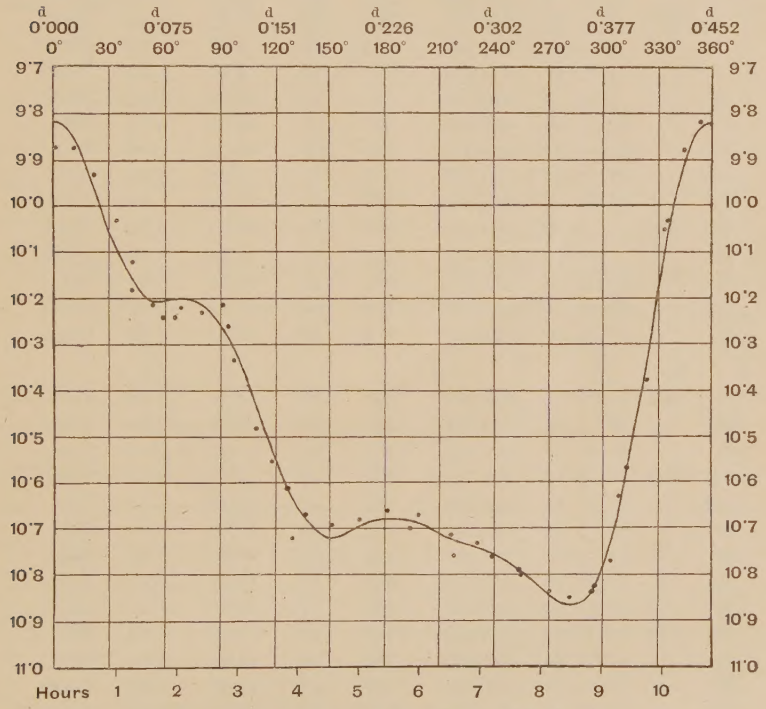


Fig. 1.—Photographic Light-Curve of RR Leonis.

5. The differences shown in the seventh column of Table II. are derived from a comparison of the observations with the curve in fig. 1. This curve represents the equation

$$m = 10{\cdot}46 + 0{\cdot}41 \sin(\theta + 237^\circ) + 0{\cdot}17 \sin(2\theta + 245^\circ) + 0{\cdot}12 \sin(3\theta + 309^\circ) + 0{\cdot}07 \sin(4\theta + 295^\circ),$$

where θ is reckoned from the adopted epoch of maximum and increases uniformly by 2π in the period of the star. The residuals tabulated indicate a probable error of $\pm 0{\cdot}018$ in a measured magnitude of the variable, and this is consistent with the corresponding figures for the comparison stars.

TABLE II.

Serial No.	Date G.M.T.				Julian Day.	Phase in Days.	Exposure.	Magn.	Obs. —Curve.	Images.
	1919.	d	h	m	2422		min.			
1	Feb.	24	8	22	014·348	·422	40	10·03	− ·02	Fair.
2		24	9	8	014·380	·002	38	9·87	+ ·05	Fair.
3		27	8	47	017·366	·274	60	10·76	+ ·04	Good.
4		27	9	53	017·412	·320	60	10·80	+ ·01	Good.
5		27	11	6	017·462	·370	60	10·83	·00	Good.
6	Mar.	5	8	39	023·361	·388	60	10·63	− ·02	Good.
7		5	9	43	023·406	·433	60	9·88	− ·03	Good.
8		5	10	50	023·452	·027	52	9·93	− ·03	Good.
9		5	12	0	023·500	·075	50	10·24	+ ·03	Good.
10		24	9	26	042·393	·420	43	10·05	− ·04	Fair.
11		27	9	51	045·411	·272	60	10·72	·00	Fair.
12		27	10	58	045·458	·319	60	10·79	·00	Good.
13		27	12	10	045·507	·368	60	10·84	·00	Good.
14	Apr.	1	9	42	050·405	·290	60	10·73	− ·02	Good.
15		1	10	53	050·454	·339	60	10·84	− ·01	Good.
16		22	11	9	071·464	·087	40	10·22	+ ·02	Fair.
17		22	12	1	071·501	·124	50	10·33	+ ·01	Good.
18		22	12	59	071·541	·164	50	10·72	+ ·08	Good.
	1920.									
19	Jan.	15	10	11	339·424	·243	44	10·70	+ ·02	Fair.
20		26	9	23	350·391	·353	50	10·85	− ·02	Fair.
21		26	10	21	350·431	·393	50	10·57	·00	Fair.
22	Mar.	10	9	15	394·385	·015	50	9·87	+ ·01	Good.
23		10	10	11	394·424	·054	43	10·12	− ·04	Fair.
24		12	8	25	396·351	·171	50	10·67	·00	Fair.
25		12	9	21	396·389	·209	50	10·68	− ·01	Bad.
26		12	10	18	396·430	·250	50	10·67	− ·02	Fair.
27		12	11	32	396·480	·300	51	10·76	+ ·01	Fair.
28	Apr.	17	10	11	432·424	·054	40	10·18	+ ·02	Fair.
29		17	10	52	432·453	·083	40	10·24	+ ·04	Fair.
30		17	11	44	432·490	·120	41	10·26	− ·03	Good.
31		17	12	31	432·521	·151	40	10·55	·00	Fair.
	1921.									
32	Feb.	25	9	12	746·383	·067	41	10·21	+ ·01	Fair.
33		25	10	0	746·417	·101	50	10·23	+ ·02	Fair.
34		25	10	55	746·455	·139	50	10·48	+ ·04	Fair.
35	Mar.	2	9	44	751 407	·115	40	10·21	− ·05	Fair.
36		2	10	48	751·451	·159	34	10·61	·00	Fair.
37		2	11	35	751·483	·191	50	10·69	− ·03	Fair.
38		2	12	29	751·521	·229	50	10·66	− ·02	Fair.
39		11	9	10	760·382	·043	50	10·03	− ·06	Good.
40		14	11	2	763·459	·405	54	10·38	+ ·01	Good.
41		29	10	14	778·427	·445	52	9·82	− ·01	Good.
42	Apr.	7	9	52	787·411	·382	56	10·77	+ ·04	Good.

Y Aurigæ.

6. The variability of Y Aurigæ was discovered by Mr. Stanley Williams* in 1901. The star, which received the provisional number 71·1901, is B.D.+42°·1295 and No. 052142 in the Harvard system. An extremely short period, with a range between mags. 8·75 and 9·65, was suggested in the first announcement, and no correction was made by Hartwig† or by v. Zeipel,‡ who observed the star in 1907. In the meantime Mr. Williams§ had

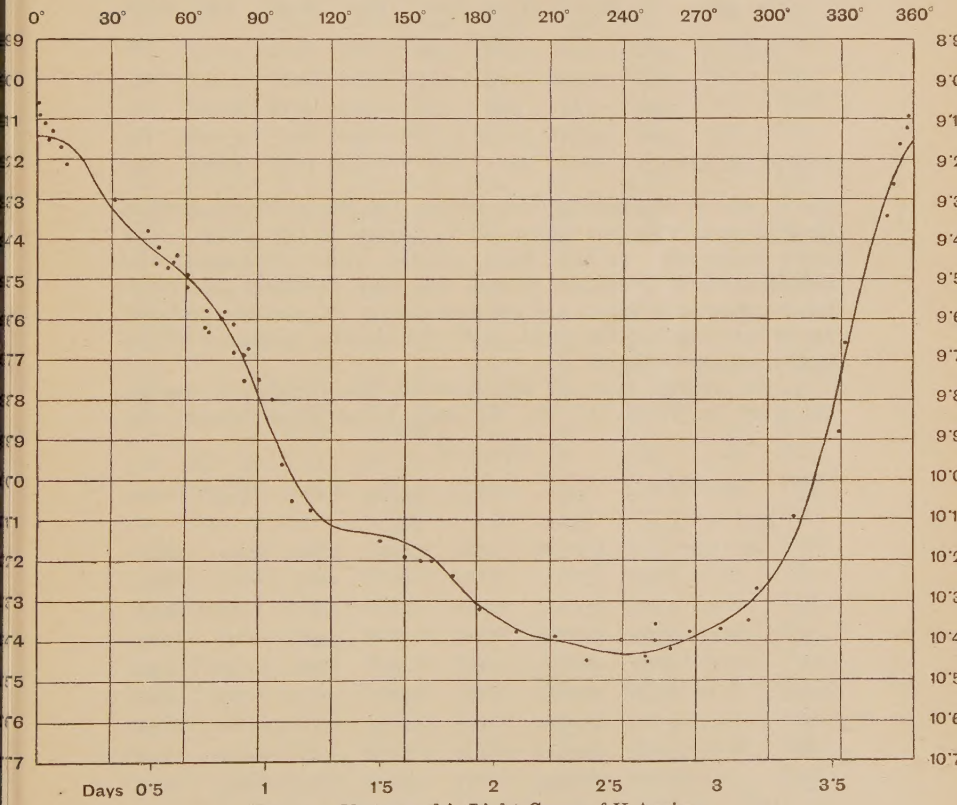


FIG. 2.—Photographic Light-Curve of Y Aurigæ.

determined approximate elements and a light curve from his own observations extending over four years.

7. The present observations at Dunsink include two maxima at J.D. 2421 580·324 and J.D. 2422 645·531, and these are separated, according to the earlier elements, by 276 periods. Hence the elements

$$\text{J.D. } 2422\ 645{\cdot}531 + 3{\cdot}859445\ E$$

* *A.N.*, 3708.
† *A.N.*, 3744.
‡ *A.N.*, 4247.
§ *M.N.*, 65, 253.

have been adopted for the maximum. The result of taking $E = -1872$ is to give a maximum at J.D. 2415 420·65, which is 0·01 day later than the final epoch determined by Mr. Williams. This agreement is entirely satisfactory; the maximum appears to be exceptionally sharp.

8. Information relating to the comparison stars is given in Table III. in the same form as in Table I. The magnitudes m_1, m_2

TABLE III.

Star.	Pl. 2021. m_1.	Pl. 2027. m_2.	Mean. m.	Corr.	Final. m'.	P.E.	Range.
B.D. +42°·1288	9·10	9·08	9·09	+·007	9·10	±·017	·10
1297	9·80	9·74	9·77	−·012	9·76	±·016	·09
1294	9·80	9·78	9·79	−·010	9·78	±·018	·13
1285	10·08	10·05	10·06	+·006	10·07	±·018	·13
Hels. ph. (Pl. 226) 192	10·70	10·71	10·71	−·001	10·71	±·010	·09

are based on Schwarzschild's system for the χ Persei cluster, photographed with the region of Y Aurigæ on two plates. The mean magnitudes m have been adopted without change in the reduction of the variable, though the plate residuals give small mean corrections which are incorporated in m', and the probable errors for a single plate which, with the extreme range, are shown in the last two columns.

9. The results from 58 exposures on the variable Y Aurigæ are given in Table IV. In the second and third columns are

TABLE IV.

Serial No.	Date G.M.T.			Julian Day.	Phase in Days.	Exposure.	Magn.	Obs. − Curve.	Images.
	1917	d	h m	2421		min.			
1	Dec.	14	7 49	577·326	0·86	40	9·68	+·02	Fair.
2		14	8 34	577·357	0·89	40	9·69	−·01	Fair.
3		14	9 12	577·383	0·92	17	9·67	−·07	Good.
4		17	6 59	580·291	3·83	40	9·12	−·05	Fair.
5		17	7 46	580·324	0·00	40	9·06	−·08	Good.
6		17	8 33	580·356	0·03	40	9·11	−·03	Good.
7		17	9 21	580·389	0·07	40	9·13	−·02	Good.
8		17	10 8	580·422	0·10	40	9·17	+·02	Good.
9		17	10 56	580·456	0·13	40	9·21	+·05	Good.
	1918								
10	Jan.	2	6 55	596·288	0·53	60	9·42	−·02	Good.
11		2	7 57	596·332	0·57	50	9·47	+·02	Good.
12		2	8 59	596·374	0·61	50	9·44	−·03	Fair.
13		2	10 0	596·417	0·66	50	9·49	−·01	Good.
14		7	7 10	601·299	1·68	60	10·20	+·02	Good.
15		7	8 20	601·347	1·73	60	10·20	·00	Good.
16		7	10 31	601·438	1·82	60	10·24	−·01	Fair.
17		8	6 53	602·287	2·67	60	10·44	+·01	Fair.
18		8	9 36	602·400	2·78	60	10·42	+·01	Fair.

TABLE IV.—*continued.*

Serial No.	Date G.M.T.				Julian Day.	Phase in Days.	Exposure.	Magn.	Obs. – Curve.	Images.
	1918	d	h	m	2421		min.			
19	Nov.	26	7	2	924·293	0·48	40	9·38	– ·04	Fair.
20		26	7	51	924·328	0·52	40	9·46	+ ·03	Fair.
21		26	9	34	924·399	0·59	40	9·46	·00	Good.
22		26	11	9	924·472	0·66	40	9·52	+ ·02	Good.
23		26	13	17	924·554	0·74	40	9·58	+ ·03	Good.
24	Dec.	4	8	31	932·354	0·82	40	9·58	– ·04	Fair.
25		4	9	25	932·393	0·86	40	9·61	– ·05	Good.
26		4	10	17	932·429	0·90	40	9·75	+ ·04	Fair.
27		4	11	55	932·496	0·97	36	9·75	– ·05	Good.
28		6	9	30	934·396	2·87	40	10·38	– ·02	Fair.
	1919				2422					
29	Nov.	12	8	41	275·362	0·34	50	9·30	– ·02	Fair.
30	Dec.	12	8	53	305·370	3·33	44	10·09	– ·05	Good.
31		18	9	0	311·375	1·61	44	10·19	+ ·03	Good.
	1920									
32	Jan.	15	8	2	339·334	2·56	44	10·40	– ·03	Fair.
33		17	8	41	341·362	0·73	40	9·62	+ ·08	Fair.
34		17	10	27	341·436	0·80	38	9·60	·00	Fair.
35		19	7	34	343·316	2·68	50	10·45	+ ·02	Good.
36		19	8	32	343·355	2·72	42	10·36	– ·07	Fair.
37		26	6	56	350·289	1·94	50	10·32	·00	Fair.
38	Feb.	21	9	35	376·400	1·03	50	9·80	– ·08	Fair.
39	Mar.	10	8	10	394·340	3·53	47	9·88	+ ·13	Fair.
40	Sept.	9	13	28	577·562	1·50	32	10·15	+ ·01	Fair.
41		16	12	42	584·530	0·75	30	9·63	+ ·07	Good.
42		18	11	42	586·488	2·71	30	10·40	– ·03	Fair.
43	Oct.	7	11	34	605·482	2·41	30	10·45	+ ·03	Fair.
44		12	11	55	610·496	3·56	30	9·66	– ·01	Fair.
45	Nov.	16	9	43	645·406	3·74	40	9·34	+ ·05	Good.
46		16	10	32	645·439	3·77	40	9·26	+ ·01	Good.
47		16	11	20	645·472	3·80	40	9·16	– ·05	Fair.
48		16	12	10	645·507	3·84	40	9·09	– ·07	Fair.
49		16	12	58	645·541	0·01	40	9·09	– ·05	Fair.
50		16	13	47	645·575	0·05	40	9·15	+ ·01	Good.
51	Dec.	28	6	13	687·259	3·13	50	10·35	+ ·04	Fair.
52		28	7	12	687·300	3·17	50	10·27	– ·02	Fair.
53		31	6	26	690·268	2·28	50	10·39	– ·01	Good.
	1921									
54	Feb.	10	12	11	731·507	1·07	56	9·96	+ ·02	Good.
55		10	13	17	731·554	1·12	56	10·05	+ ·06	Fair.
56		10	15	24	731·642	1·20	60	10·07	·00	Good.
57	Mar.	11	10	53	760·454	3·00	60	10·37	+ ·01	Good.
58		14	10	2	763·418	2·10	56	10·38	·00	Fair.

recorded the astronomical date and G.M.T., together with the Julian day and decimal fraction, corresponding to the middle of each exposure, the length of which is shown in the fifth column. The phase in days, given in the fourth column, is reckoned from the preceding maximum according to the elements adopted in § 7. The deduced photographic magnitude of Y Aurigæ appears in the sixth column.

10. The differences shown in the seventh column of Table IV. are derived from a comparison of the observations with the curve in fig. 2. This curve represents the equation

$$m = 9{\cdot}96 + 0{\cdot}57 \sin(\theta + 237^\circ) + 0{\cdot}20 \sin(2\theta + 244^\circ) + 0{\cdot}06 \sin(3\theta + 258^\circ) + 0{\cdot}06 \sin(4\theta + 309^\circ) + 0{\cdot}04 \sin(5\theta + 275^\circ),$$

where θ is reckoned from the adopted epoch of maximum and increases uniformly by 2π in the period of the star. The residuals tabulated indicate a probable error of $\pm{\cdot}028$ in a measured magnitude of the variable. This is rather a high value, as shown by the internal consistency of the comparison stars, and the curve fails to represent in particular the pointed maximum very clearly indicated by the observations. Precise details like this require a number of small harmonic terms of a high order, which together have no influence on the general run of the curve and individually have no interest. The photographic range appears to be 1·4 mags., while the visual is only 1·0. The difference is quite normal, and consistent with the change of colour and type with magnitude, which Mr. Williams suspected at an early stage in his observations.

UU Cassiopeiæ.

11. The variability of UU Cassiopeiæ was discovered by Luizet* in 1913, and the star received the provisional number 10·1913. This star is B.D. +60°·2629, and both it and B.D. +60°·2631 were used by Luizet as comparison stars for B.D. +60°·2634, which is a known variable of long period, discovered in 1911. In the course of these observations B.D. +60°·2629 proved sometimes brighter, sometimes fainter than B.D. +60°·2631. Luizet concluded that the former was a short-period variable of the type of δ Cephei, with a range of about half a magnitude and more rapid variation near minimum than near maximum.

12. Preliminary elements referring to minimum were given by Luizet. For the present series the elements for maximum

$$\text{J.D. } 2422\ 745{\cdot}09 + 4{\cdot}31304\ \text{E}$$

have been adopted. The period was found to reconcile the observations on the ascending branch in the neighbourhood of mag. 9·95. The epoch of maximum is not well defined by the observations. The minimum falls some 2·5 days later, and should be rather more certain. Hence with $\text{E} = -773$ a minimum should

* *A.N.*, 4641.

have occurred at J.D. 2419 413·6, which precedes Luizet's epoch, 1912 Jan. 12·1, by half a day. It is quite possible that the minimum should be placed a little later in the curve, and it may be that the period now adopted is rather too large, if indeed it

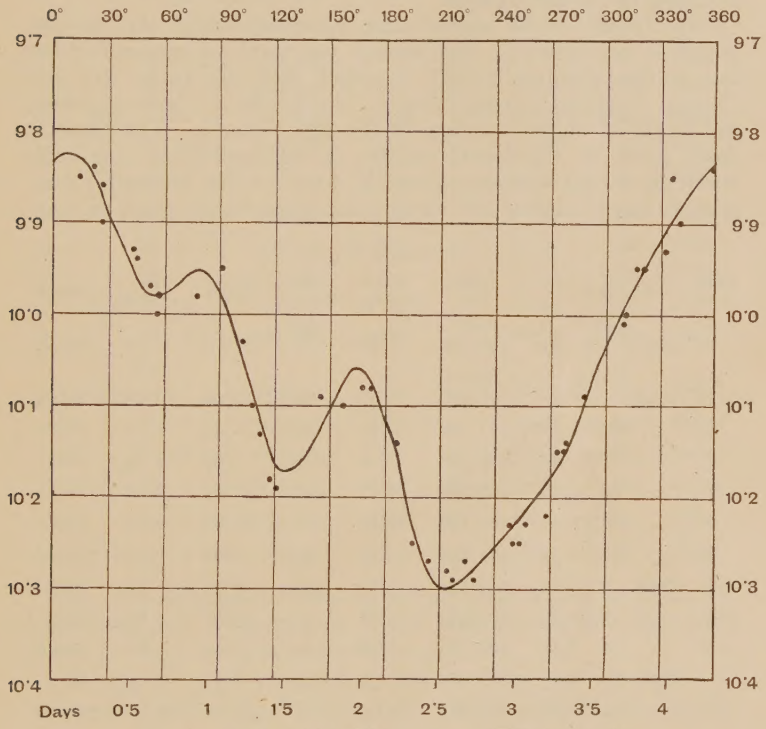


FIG. 3.—Photographic Light-Curve of UU Cassiopeiæ.

is to be regarded as constant. Luizet's preliminary period was 4·314 days.

13. Information relating to the comparison stars is contained in Table V. The magnitudes m_1, m_2 are based on Schwarzschild's system for the χ Persei cluster, which was photographed with the region of UU Cassiopeiæ on two plates with exceptionally accordant results, a systematic difference being commonly introduced in this process. The mean magnitudes m

TABLE V.

Star.	Pl. 1839. m_1.	Pl. 2084. m_2.	Mean. m.	Corr.	Final. m'.	P.E.	Range.
B.D. +60°·2632	9·51	9·52	9·51	+·006	9·52	±·015	·08
2635	10·02	10·03	10·02	−·008	10·01	±·020	·12
+59·2772	10·25	10·25	10·25	+·002	10·25	±·013	·12
Vat. ph. +61°·39486	10·55	10·56	10·55	+·001	10·55	±·014	·10

are those which have been adopted in the reduction of the variable. The residuals from each plate provide the mean corrections which give the adjusted magnitudes m' and the probable errors for a single plate. For each star the extreme range of these residuals is shown in the last column.

14. Details of the results from 44 exposures on the variable are given in Table VI. The second and third columns record the astronomical date and G.M.T., together with the Julian day and decimal fraction, corresponding to the middle of each exposure, the length of which is shown in the fifth column. The phase in days, given in the fourth column, is reckoned from maximum according to the elements given in § 12. The deduced photographic magnitudes of UU Cassiopeiæ appear in the sixth column.

TABLE VI.

Serial No.	Date G.M.T.	Julian Day.	Phase in Days.	Exposure.	Magn.	Obs. – Curve.	Images.
	1917.	2421.		min.			
1	Nov. 7 10 35	540·442	3·00	40	10·25	+ ·02	Good.
	1919.	2422.					
2	Aug. 5 10 31	176·438	0·67	30	10·00	+ ·02	Good.
3	20 10 44	191·449	2·74	30	10·29	+ ·02	Fair.
4	27 10 25	198·435	1·10	15	9·95	− ·04	Fair.
5	29 9 36	200·400	3·07	30	10·23	+ ·02	Fair.
6	29 12 40	200·528	3·20	40	10·22	+ ·03	Fair.
7	30 9 34	201·399	4·07	32	9·90	+ ·01	Fair.
8	Sept. 3 10 24	205·434	3·79	30	9·95	− ·02	Good.
9	3 11 59	205·499	3·85	30	9·95	·00	Good.
10	20 8 41	222·362	3·46	40	10·09	·00	Good.
11	Nov. 12 6 46	275·282	0·32	44	9·90	+ ·03	Fair.
12	13 6 21	276·264	1·30	44	10·10	+ ·01	Good.
13	19 6 55	282·288	3·01	41	10·25	+ ·02	Fair.
14	26 8 35	289·358	1·45	31	10·19	+ ·02	Good.
15	Dec. 12 7 51	305·328	0·17	44	9·85	+ 02	Good.
16	12 9 47	305·408	0·25	40	9·84	− ·01	Good.
	1920.						
17	Jan. 15 8 58	339·374	4·02	44	9·85	− ·05	Good.
18	17 9 34	341·399	1·74	40	10·09	− ·03	Fair.
19	Sept 9 9 35	577·400	0·52	30	9·93	− ·03	Good.
20	9 10 6	577·421	0·54	30	9·94	− ·02	Good.
21	9 12 0	577·500	0·62	30	9·97	− ·01	Fair.
22	16 11 18	584·471	3·28	30	10·15	− ·02	Good.
23	18 10 21	586·431	0·93	30	9·98	+ ·03	Fair.
24	Oct. 7 7 55	605·320	2·56	30	10·28	− ·02	Good.
25	7 8 25	605·348	2·59	30	10·29	− ·01	Good.
26	9 9 14	607·385	0·31	30	9·86	− ·01	Fair.

TABLE VI.—*continued.*

Serial No.	Date G.M.T.				Julian Day.	Phase in Days.	Exposure.	Magn.	Obs.—Curve.	Images.
	1920.				2422.		min.			
27	Oct.	12	9	21	610·389	3·32	30	10·15	·00	Fair.
28		12	9	52	610·411	3·34	30	10·14	−·01	Good.
29		13	8	31	611·354	4·28	30	9·84	·00	Fair.
30		18	9	5	616·379	0·68	30	9·98	·00	Fair.
31	Nov.	5	6	58	634·291	1·34	34	10·13	+·01	Fair.
32		10	6	37	639·276	2·01	34	10·08	+·02	Fair.
33		10	8	7	639·337	2·07	34	10·08	−·02	Fair.
34		10	11	30	639·479	2·22	32	10·14	·00	Fair.
35		16	7	0	645·292	3·72	40	10·00	+·01	Fair.
36		16	8	44	645·365	3·79	40	9·95	−·01	Good.
37	Dec.	10	8	9	669·339	1·89	40	10·10	+·03	Fair.
38		28	9	10	687·382	2·68	40	10·27	−·02	Fair.
	1921.									
39	Jan.	6	7	30	696·313	2·98	44	10·23	·00	Fair.
40		11	8	23	701·349	3·70	50	10·01	+·01	Fair.
41		13	8	42	703·363	1·41	50	10·18	+·03	Fair.
42		14	7	4	704·295	2·34	60	10·25	+·02	Good.
43		14	9	32	704·397	2·44	60	10·27	−·01	Fair.
44	Feb.	25	7	41	746·321	1·23	44	10·03	−·02	Fair.

15. The differences shown in the seventh column of Table VI. are derived from a comparison of the observations with the curve in fig. 3. This curve represents the equation

$$m = 10{\cdot}06 + 0{\cdot}18 \sin(\theta + 246^\circ) + 0{\cdot}06 \sin(2\theta + 300^\circ) + 0{\cdot}02 \sin(3\theta + 104^\circ) + 0{\cdot}04 \sin(4\theta + 301^\circ) + 0{\cdot}03 \sin(5\theta + 177^\circ),$$

where θ is reckoned from the adopted epoch of maximum and increases uniformly by 2π in the period of the star. The residuals tabulated indicate a probable error of $\pm{\cdot}014$, showing that in this case the curve does full justice to the observations. It is well that this should be so, since the total range is under half a magnitude. An uncommon feature is to be noticed in the third term, of which the coefficient is smaller than those of the following terms. This occurs also in X Lacertæ and RW Cassiopeiæ.

16. The equations of the light curves may also be written, after a change of origin, in the form

$$m = m_0 - m_1 \cos\phi + m_2 \cos(2\phi - \phi_2) + \ldots$$

The three stars discussed above then give the figures:

Star.	Period.	ϕ_1.	ϕ_2.	ϕ_3.	$\phi_2 - 0{\cdot}6\phi_3$.
		°	°	°	°
RR Leonis	$10^h{\cdot}9$	180	139	42	114
Y Aurigæ	$3^d{\cdot}9$	180	140	93	84
UU Cassiopeiæ	$4^d{\cdot}3$	180	102	274	...

These form an addition to Table III. of a paper * on Y Lacertæ. The first two are normal members of Group II.; the third is interesting as belonging to Group I. Its nearest parallel among long-period variables is R Serpentis ($\phi_2 = 83°$, $\phi_3 = 248°$, Phillips) and among cluster variables possibly Bailey's No. 57 in M15 ($\phi_2 = 111°$, $\phi_3 = 267°$), for which also the coefficient of the third term is extremely small.

17. Parallel sequences in the phases of different stars may be of interest. The following two pairs are selected from a list of fifteen stars, the phases being here reckoned from the adopted maxima:

Star.	θ_1.	θ_2.	θ_3.	θ_4.	θ_5.
	°	°	°	°	°
RR Leonis	237	245	309	295	...
SW Draconis	239	242	307	302	310
XZ Cygni	231	239	258	269	290
Y Aurigæ	237	244	258	309	275

The coefficients seem less significant. But it was suggested † that some resemblance could be traced in the terms of the third and higher orders, of the type

$$\Delta m = -0{\cdot}48 \cos 3\phi - 0{\cdot}31 \cos 4\phi - 0{\cdot}21 \cos 5\phi.$$

Further examples can now be given.

(*a*) The factor $\frac{1}{6}$ and $\phi = \theta + 10°$ lead to

$$0{\cdot}08 \sin (3\theta + 300°) + 0{\cdot}05 \sin (4\theta + 310°) + 0{\cdot}03 \sin (5\theta + 320°),$$

and the corresponding terms for SW Andromedæ ‡ are

$$0{\cdot}09 \sin (3\theta + 285°) + 0{\cdot}05 \sin (4\theta + 346°),$$

the fifth term being small ($< 0{\cdot}2$) as in RR Lyræ.

(*b*) The factor $\frac{1}{4}$ and $\phi = \theta + 10°$ lead to

$$0{\cdot}12 \sin (3\theta + 300°) + 0{\cdot}08 \sin (4\theta + 310°) + 0{\cdot}05 \sin (5\theta + 320°),$$

and the corresponding terms of RR Leonis are

$$0{\cdot}12 \sin (3\theta + 309°) + 0{\cdot}07 \sin (4\theta + 295°),$$

the fifth term being again small.

(*c*) The factor $\frac{1}{5}$ and $\phi = \theta$ lead to

$$0{\cdot}10 \sin (3\theta + 270°) + 0{\cdot}06 \sin (4\theta + 270°) + 0{\cdot}04 \sin (5\theta + 270°),$$

and the corresponding terms of Y Aurigæ are

$$0{\cdot}06 \sin (3\theta + 258°) + 0{\cdot}06 \sin (4\theta + 309°) + 0{\cdot}04 \sin (5\theta + 275°).$$

* *M.N.*, 80, 38. † *M.N.*, 79, 194.
‡ *M.N.*, 80, 212.

(*d*) The factor $\frac{1}{8}$ and $\phi = \theta + 190^\circ$ lead to

$$0^{\cdot}06 \sin (3\theta + 120^\circ) + 0^{\cdot}04 \sin (4\theta + 310^\circ) + 0^{\cdot}03 \sin (5\theta + 140^\circ),$$

and the corresponding terms of UU Cassiopeiæ are

$$0^{\cdot}02 \sin (3\theta + 104^\circ) + 0^{\cdot}04 \sin (4\theta + 301^\circ) + 0^{\cdot}03 \sin (5\theta + 177^\circ).$$

(*e*) The factor $\frac{1}{4}$ and $\phi = \theta + 7^\circ$ lead to

$$0^{\cdot}12 \sin (3\theta + 291^\circ) + 0^{\cdot}08 \sin (4\theta + 298^\circ) + 0^{\cdot}05 \sin (5\theta + 305^\circ),$$

and the corresponding terms of V Lacertæ * are

$$0^{\cdot}12 \sin (3\theta + 294^\circ) + 0^{\cdot}07 \sin (4\theta + 265^\circ) + 0^{\cdot}05 \sin (5\theta + 317^\circ).$$

Such suggestions are probably of slight value, but it is natural to look for evidences of association among these higher terms.

Observations of V Cassiopeiæ (*Ch.* 8324) *in* 1916–21.

By A. N. Brown, M.A.

The 228 observations of the long-period variable V Cassiopeiæ given below are in continuation of those published in *Monthly Notices*, **76**, 606–612. Light curves have been drawn from them, from which it appears that eight maxima and eight minima occurred between 1916 May 8 and 1921 April 12.

Maxima.			Minima.		
Date.	Julian Date.	Mag.	Date.	Julian Date.	Mag.
1916 June 8	1023	8·2	1916 October 11	1148	12·5
1917 January 24	1254	8·0	1917 May 31	1380	12·4
1917 September 12	1484	6·7	1918 January 15±	1609	...
1918 May 2	1716	8·2	1918 August 25±	1831	<12·3
1918 December 17	1945	8·2	1919 April 17	2066	12·0
1919 August 2	2173	7·6	1919 November 30±	2293	...
1920 March 13	2397	7·8	1920 July 18	2524	12·2
1920 November 7	2636	8·2	1921 February 23	2744	12·2

The third, fourth, and sixth of the above minima are indicated as uncertain owing to paucity of observations, due either to the weather, or to the fact that the phases in question occurred at a time when I was away from here, and therefore unable to use my larger telescope. The period derived from the observations extending over these five years is 229 days.

In the third column of the records given below the comparisons were for the most part made by the "fractional" method, but

* *M.N.*, 76, 240.

each is here expressed in steps, the value of a step in every case being ·1 magnitude. Sometimes, however, fractional and step estimates were made upon the same occasion, and in order to distinguish the two methods from each other a semicolon has been placed between each separate estimate, fractional or step. Thus on 1916 May 8 three fractional estimates are shown; on May 19 one fractional followed by one step; on July 8 there are three step estimates. All the comparison stars used are numbered as in Hagen's *Atlas*, the negative sign after the comparison star implying that the variable was fainter, the positive sign that it was brighter than the star in question. As regards the magnitudes of the comparison stars, the Harvard values have been adopted throughout, those values having been obtained from the column headed H.P. in series vi. of Hagen's *Atlas Stell. Var.* In the last column the magnitude deduced from the comparisons is given, a mean being taken when two or more separate estimates have been made. In such cases fractional and step estimates are given equal weight.

The majority of these observations were made with a 5-inch refractor with powers varying from 25 to 200, but sometimes at the brighter stages, and when it was impossible to use the larger instrument, estimates were made with a 3-inch refractor.

The Observations.

Date.	Julian Date.	Comparisons.	Ded. Mag.
1916			
May 8	0992	6 − 1, 12 + 4; 7 − 2, 11 + 2; = 8, 10 + 1	8·8
15	0999	5 − 1, 7 + 1	8·5
19	1003	5 − 1, 7 + 1; 6 + 2	8·4
28	1012	4 − 4, 5 + 1	8·2
June 6	1021	4 − 4, 5 + 1	8·2
21	1036	4 − 5, 5 + 1	8·2
25	1040	7 − 0·5	8·7
30	1045	5 − 1, 7 + 1	8·5
July 3	1048	5 − 1; 7 + 2	8·4
8	1053	5 − 2; 7 + 1; 8 + 2	8·5
22	1067	6 − 4·5, 12 + 1; 11 + 1	9·0
29	1074	17 − 1, = 21	9·8
Aug. 4	1080	17 − 1, = 21; 22 + 1; 24 + 1	9·8
19	1095	43 − 2, 51 + 1	11·1
27	1103	55 − 2	11·6
Sept. 4	1111	64 − 2	12·0
Sept. 18	1125	63 − 1, = 69	12·0
21	1128	69 − 2, 73 + 1	12·2
Oct. 15	1152	73 − 2	12·5
20	1157	73 − 1	12·4
28	1165	69 − 2·5, 73 + 1	12·2
31	1168	69 − 2·5, 73 + 1	12·2
Nov. 2	1170	69 − 1, 73 + 1	12·2
16	1184	51 + 1	11·1
20	1188	32 − 5, 43 + 1	10·8
24	1192	32 − 4, 43 + 2; 34 − 1, 40 + 2	10·6
26	1194	22 − 1, 34 + 3; 32 + 2	10·1
Dec. 3	1201	10 − 7, 24 + 2; 17 − 1·5, 21 + 1	9·7
26	1224	8 − 1, = 10	9·0
1917			
Jan. 4	1233	6 − 1; 7 − 1	8·7
10	1239	5 − 1, 6 + 2	8·4
27	1256	4 − 3, 5 + 3	8·0

The Observations—continued.

Date.	Julian Date.	Comparisons.	Ded. Mag.
1917			
Feb. 6	1266	4 − 4, 5 + 1	8·2
9	1269	4 − 5, 5 + 1	8·2
14	1274	4 − 4·5, 5 + 1	8·2
26	1286	6 − 4, 12 + 2; 7 − 3·5, 11 + 2	9·0
Mar. 14	1302	17 − 1, = 21; 24 + 1	9·8
19	1307	22 − 3·5, 34 + 2	10·2
22	1310	22 − 4, 34 + 1	10·3
27	1315	34 − 1, 40 + 2	10·5
Apr. 15	1334	43 − 2·5, 51 + 1	11·1
21	1340	51 − 1, 55 + 0·5	11·3
25	1344	55 − 2, 64 + 2	11·6
May 8	1357	64 − 1, = 69	12·0
24	1373	Glimpsed. < 69	< 12·0
28	1377	73 − 1	12·4
June 8	1388	= 73	12·3
12	1392	73 + 0·5	12·3
17	1397	69 − 2, 73 + 0·5	12·2
21	1401	69 − 2, 73 + 1	12·2
26	1406	55 − 3, 64 + 1	11·7
July 1	1411	= 51	11·2
6	1416	34 − 4, 43 + 1	10·8
15	1425	17 − 3, 32 + 4	9·9
19	1429	= 17	9·6
22	1432	15 − 1, 17 + 0·5	9·6
25	1435	6 − 5, 12 + 1; = 11	9·1
Aug. 11	1452	4 − 4, 5 + 1	8·2
14	1455	4 − 4, 5 + 1	8·2
18	1459	4 − 1, 5 + 4	7·9
22	1463	4 + 1	7·6
Sept. 1	1473	3 − 10, 4 + 4	7·3
8	1480	3 − 11, 4 + 4	7·4
12	1484	3 − 3, 4 + 10	6·7
14	1486	3 − 9, 4 + 4·5	7·2
15	1487	3 − 10, 4 + 3	7·4
19	1491	3 − 11, 4 + 2	7·5
20	1492	3 − 11, 4 + 2	7·5
Sept. 24	1496	3 − 11, 4 + 2	7·5
Oct. 5	1507	5 + 1·5	8·2
7	1509	= 5	8·3
23	1525	8 − 5, 15 + 1·5	9·3
Nov. 4	1537	22 − 4, 34 + 1·5	10·3
7	1540	22 − 4, 34 + 0·5	10·3
14	1547	34 − 2, 40 + 1	10·6
Dec. 2	1565	= 51	11·2
7	1570	55 − 2·5, 64 + 1	11·7
11	1574	64 − 0·5, 69 + 1	11·9
17	1580	69 − 2, 73 + 0·5	12·2
1918			
Jan. 3	1597	Not seen. < 69	< 12·0
20	1614	73 − 4; 75 − 3	12·7
30	1624	69 − 5; 75 − 2	12·6
Feb. 1	1626	69 − 3; 75 − 1	12·4
8	1633	64 − 1, = 69	12·0
16	1641	43 − 1, 51 + 1	11·1
22	1647	43 − 1, 51 + 1	11·1
28	1653	34 − 4, 43 + 1	10·8
Mar. 7	1660	34 − 1; 40 + 3	10·5
15	1668	25 − 1, 34 + 3; 22 − 1; 32 + 2	10·1
24	1677	= 15; 17 + 1; 19 + 2	9·5
30	1683	6 − 4, 12 + 1; 7 − 4, 11 + 1	9·0
Apr. 6	1690	6 − 2; 7 − 1, 11 + 4; 8 + 2	8·7
12	1696	5 − 2; 6 + 2; 7 + 2	8·4
14	1698	5 − 1, 7 + 1	8·5
18	1702	5 − 1, 7 + 2	8·4
26	1710	4 − 5, 5 + 1	8·2
May 2	1716	4 − 4, 5 + 1	8·2
8	1722	4 − 5, 5 + 1	8·2
12	1726	4 − 3; 5 + 1; 7 + 5	8·1
28	1742	7 − 3, 10 + 1	8·9
June 2	1747	6 − 5, 12 + 1; = 11	9·1

The Observations—continued.

Date.	Julian Date.	Comparisons.	Ded. Mag.
1918			
June 10	1755	15 − 0·5, 17 + 0·5	9·6
13	1758	15 − 0·5, 19 + 1	9·6
22	1767	22 − 3·5, 34 + 2	10·2
29	1774	= 34	10·4
July 2	1777	40 − 0·5, 44 + 1	10·8
8	1783	= 51	11·2
12	1787	51 − 1, 55 + 1	11·3
18	1793	55 − 3, 64 + 1	11·7
29	1804	Glimpsed. <64	<11·8
Aug. 9	1815	Glimpsed. <69	<12·0
Sept. 1	1838	Not seen. <73	<12·3
25	1862	69 − 1, 73 + 1	12·2
28	1865	64 − 1, = 69	12·0
Oct. 3	1870	64 − 1, 69 + 1	11·9
6	1873	= 55	11·4
8	1875	51 − 1, 55 + 1	11·3
13	1880	= 43	10·9
Nov. 1	1899	22 − 2, 32 + 2	10·1
7	1905	22 − 1, 34 + 4	10·0
13	1911	17 − 1, 21 + 1	9·7
15	1913	15 − 0·5, 17 + 0·5	9·6
29	1927	= 5	8·3
Dec. 7	1935	4 − 5; 5 + 1	8·2
20	1948	5 + 1	8·2
23	1951	5 + 1	8·2
29	1957	5 + 1	8·2
1919			
Jan. 1	1960	= 5	8·3
5	1964	5 − 1, 7 + 2	8·4
17	1976	6 − 3, 12 + 2; 7 − 2; 11 + 3	8·9
22	1981	11 − 1; = 12	9·2
Feb. 8	1998	= 21	9·8
Mar. 6	2024	43 − 1, 51 + 2	11·0
26	2044	64 − 1·5	12·0
Apr. 2	2051	= 69	12·0
24	2073	Not seen. <64	<11·8
May 4	2083	= 69	12·0
1919			
May 12	2091	64 − 1	11·9
19	2098	43 − 2; 51 + 1	11·1
22	2101	= 43	10·9
28	2107	22 − 4, 34 + 1	10·3
30	2109	22 − 3, 34 + 2	10·2
June 3	2113	22 − 1·5, 34 + 4	10·0
9	2119	7 − 4, 11 + 1	9·0
11	2121	6 − 4, 12 + 1; 10 − 1; 11 + 1	9·1
16	2126	7 − 1·5, 11 + 3	8·8
21	2131	7 − 2, 11 + 2	8·9
26	2136	5 − 2, 7 + 1	8·5
July 15	2155	4 − 2, 5 + 4	7·9
22	2162	4 − 1, 5 + 4	7·9
30	2170	4 + 1	7·6
Aug. 6	2177	4 + 1	7·6
9	2180	4 − 1	7·8
15	2186	4 − 4, 5 + 2	8·1
21	2192	4 − 4·5, 5 + 1	8·2
27	2198	5 − 2, = 7	8·6
Sept. 6	2208	7 − 3·5, 11 + 1; = 10	9·0
9	2211	6 − 4, 12 + 1; 7 − 4, 11 + 1	9·0
17	2219	= 15; 19 + 3	9·5
19	2221	15 − 1; 19 + 2·5	9·5
26	2228	15 − 1, 17 + 0·5	9·6
Oct. 2	2234	17 − 1·5, 21 + 1	9·7
14	2246	22 − 3·5, 34 + 2	10·2
26	2258	32 − 4, 43 + 2	10·7
31	2263	43 − 1, 51 + 2	11·0
Nov. 21	2284	64 − 1, 69 + 1	11·9
Dec. 19	2312	55 − 2·5, 64 + 1	11·7
29	2322	51 + 1·5	11·1
1920			
Jan. 16	2340	32 − 0·5, 34 + 1	10·3
19	2343	= 21; 22 + 1	9·8
21	2345	17 − 1, 21 + 1	9·7

The Observations—continued.

Date.	Julian Date.	Comparisons.	Ded. Mag.
1920			
Jan. 24	2348	15 − 1, 17 + 0·5	9·6
Feb. 6	2361	6 − 4·5, 12 + 1; 7 − 4, 11 + 1	9·0
11	2366	6 − 2, 12 + 4; 7 − 1·5, 11 + 3	8·8
17	2372	5 − 2·5, 7 + 1; 6 + 1·5	8·5
Mar. 7	2391	4 − 1, 5 + 5	7·8
12	2396	4 − 1, 5 + 5	7·8
18	2402	4 − 2, 5 + 4	7·9
20	2404	4 − 1, 5 + 5	7·8
22	2406	4 − 1, 5 + 5	7·8
31	2415	4 − 3, 5 + 3	8·0
Apr. 12	2427	5 − 1, 7 + 2	8·4
16	2431	6 − 3, 12 + 3; 7 − 2, 11 + 2; 8 − 0·5, 10 + 1	8·9
21	2436	6 − 4, 12 + 2; 7 − 3·5, 11 + 1	9·0
28	2443	6 − 2, = 9	8·9
May 4	2449	= 15	9·5
13	2458	21 − 0·5, 22 + 0·5	9·9
19	2464	32 − 1, 34 + 0·5	10·4
23	2468	32 − 4, 43 + 2	10·7
June 6	2482	= 51	11·2
8	2484	51 − 1, 55 + 1	11·3
18	2494	55 − 3, 64 + 1	11·7
July 14	2520	69 − 2·5, 73 + 1	12·2
18	2524	69 − 2·5, 73 + 1	12·2
24	2530	69 − 2·5, 73 + 1	12·2
Aug. 9	2546	69 − 1, 73 + 2	12·1
15	2552	51 − 1, 55 + 1	11·3
19	2556	43 − 2, 51 + 1	11·1
Aug. 26	2563	32 − 3, 43 + 3	10·6
Sept. 5	2573	22 − 4; 32 + 1; 34 + 2	10·2
10	2578	22 − 1·5, 32 + 3	10·0
12	2580	22 − 0·5	10·0
16	2584	= 22	9·9
19	2587	17 − 1·5, 21 + 1; 22 + 1	9·8
Oct. 2	2600	15 + 1	9·4
10	2608	7 − 3·5, 11 + 2	8·9
23	2621	4 − 4, 5 + 1	8·2
Nov. 1	2630	4 − 4, 5 + 1	8·2
4	2633	4 − 4, 5 + 1	8·2
11	2640	4 − 4, 5 + 1	8·2
20	2649	4 − 4·5, 5 + 1	8·2
23	2652	4 − 4·5, 5 + 1	8·2
Dec 3	2662	7 − 3, 11 + 1·5	8·9
9	2668	15 − 0·5, 17 + 0·5	9·6
28	2687	34 + 1	10·3
1921			
Jan. 12	2702	51 + 1	11·1
31	2721	64 − 3; = 69	12·1
Feb. 2	2723	= 69	12·0
14	2735	Not seen. < 64	< 11·8
26	2747	69 − 2·5, 73 + 1	12·2
Mar. 2	2751	69 − 2·5, 73 + 1	12·2
18	2767	64 − 1·5, 69 + 1	11·9
24	2773	55 − 3, 64 + 1·5	11·7
26	2775	55 − 2·5, 64 + 2	11·6
30	2779	51 − 1	11·3
Apr. 3	2783	51 − 1, 55 + 1	11·3
7	2787	55 − 1	11·5
12	2792	= 55	11·4

[Table

The Comparison Stars Used.

Hagen's Number.	H.P. Magnitude.	Hagen's Number.	H.P. Magnitude.	Hagen's Number.	H.P. Magnitude.
3	6·3	15	9·5	43	10·9
4	7·7	17	9·6	44	10·9
5	8·3	19	9·7	51	11·2
6	8·6	21	9·8	55	11·4
7	8·6	22	9·9	63	11·8
8	8·8	24	9·9	64	11·8
9	8·9	25	10·0	69	12·0
10	9·0	32	10·3	73	12·3
11	9·1	34	10·4	75	12·4
12	9·2	40	10·7		

Ludgrove, New Barnet, Herts:
1921 *April* 29.

The Orbit of Σ 554 = 80 *Tauri.* By W. H. van den Bos.

(*Communicated by Professor W. de Sitter.*)

Among the binary stars of which the observed arc is long enough to make the computation of an orbit possible, 80 Tauri is of special interest as a member of the Hyades.

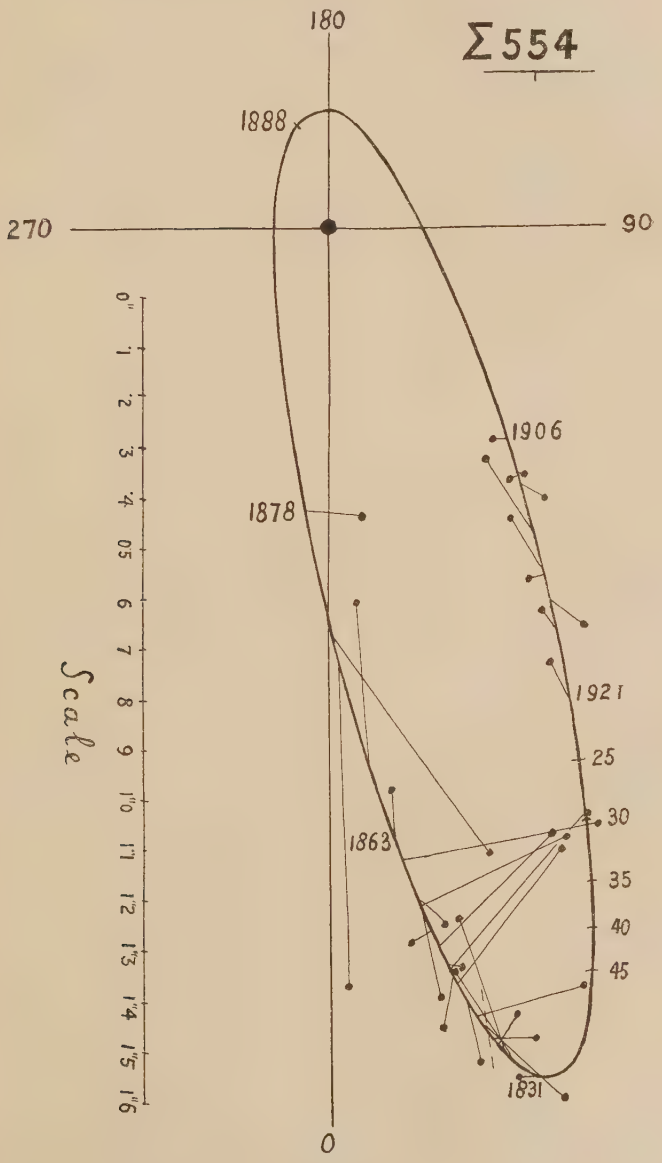
The star has been observed as a double star since the time of Struve, and the older measures made it probable that it was then near its maximum separation.

The apparent orbit being a very elongated ellipse, broken in two pieces by the disappearance of the companion in the rays of the much brighter primary, the method of T. N. Thiele (*A.N.*, Bd. 104, No. 2488) has been chosen, which requires in this case three normal places and the constant of areal velocity. The older position-angles are too bad to give a reliable value for this constant, but after Professor Aitken kindly completed my list of modern observations the computation could be undertaken.

The position-angles (corrected for precession to 1925) and the distances were plotted, the times of observation being the abscissæ, and interpolation curves drawn. From these were taken the values of s and $\frac{dp}{dt}$ for the dates 1835, 1845, 1855, 1865, and for 1907, 1909, 1911, . . . 1921.

The mean value of $s^2\frac{dp}{dt}$, −0·009103 (s being expressed in seconds of arc, $\frac{dp}{dt}$ in radians per annum) is adopted as the constant of areal velocity.

By means of this value the interpolation curves are improved, the measures themselves indicating where the distance-curve should be corrected by means of the angles (this was in general after



Orbit of Σ 554.

1906), and where, on the contrary, the distances are more trustworthy (generally from 1831 to 1878).

Finally, interpolation curves are found which

(1) satisfy the measures as well as possible ;
(2) satisfy the law of areas precisely ;
(3) give regular first and second differences.

The apparent orbit, and therefore the true orbit also, is based on these curves.

This method of determining the apparent orbit has the advantage that it does not mix up errors of position-angle with errors of distance, and pays full respect to the law of areas. Professor Aitken's objection to Herschel's method (*The Binary Stars*, p. 71) does not hold here, because the measures of distance, if they are good enough, are used to correct the angles.

I take from the curves four normal places:

I.	1830·00	373°·8	1″·745
II.	1878·00	356·7	0·595
III.	1906·00	40·3	0·535
IV.	1921·00	27·0	1·063

I have derived two sets of elements, given below, Set (A) depending on the normal places I., II., and IV.; Set (B) on I., III., and IV.

This has been done because I feared that the two pieces of the interpolation curve of angles might have been wrongly adjusted against each other. This may happen without apparent conflict with the law of areas, for we can alter all angles by the same quantity without changing any value of $\frac{dp}{dt}$. This will only cause a slight rotation of the apparent orbit if the whole arc has been observed, but in this case the observed portions may be affected by different quantities, which will change the form of the apparent orbit also.

This error will reveal itself in a difference between the two sets.

	Elements (A).	Elements (B).
P	148·3 years	150·2 years
e	0·790	0·728
T	1888·30	1886·84
a	1″·036	1″·060
i	±71°·0	±73°·7 angles decreasing
Ω	8°·88	11°·80
ω	157°·92	162°·38
$p_h = aP^{-\frac{2}{3}}$	0″·0370	0″·0376

The difference between the two sets is small enough ; orbit (A) will, of course, satisfy the older, (B) the modern measures better.

Computing from (B) the position of the companion at the time of Burnham's measure in 1878, I find 296°·3 0″·17. Now it is quite certain that, had the distance been so small, Burnham could not have separated the pair. An intermediate set of elements, (2A + 3B) : 5, gives 352°·1 0″·43, which seems also too small a distance to have been measured for this pair, remembering, *e.g.*, Hussey's failure to separate the pair in 1904 with the 36-inch.

I therefore adopt Set (A) as the best orbit to be computed at present.

Measures and Residuals, Observed – Computed.

Date.	Obs.	Apert.	Pos.-Ang. 1925.		Res.	Dist.		Res.
			°		°	″		″
1831·18	Struve	9″·6	13·4	4n	−0·1	1″·74	4n	0″·00
36·96	Dawes	3¾	10·2	2n	−2·4	1·5 ?	In	−0·20
37·22	Smyth	6	11·5		−1·1	1·4		−0·30
39·16	,,		14·3		+2·1	1·6		−0·08
40·10	Dawes	7	15·2	2n	+3·2	1·67	In	0·00
43·11	Smyth	6	16·0		+4·6	1·8		+0·16
43·78	Dawes	7	11·9	4n	+0·5			
44·79	Mädler	9·6	19·4	3n	+8·3 !	1·60	3n	−0·02
48·09	Dawes	7	11·0	In	+0·6	1·7 ?	In	+0·12
51·14	Mädler	9·6	21·6	2n	+11·8 !	1·33	2n	−0·19
51·85	O. Str.	15	obs. 6·2	In	−3·4	1·51	In	0·00
			corr. 8·8		−0·8	1·61		+0·10
52·15	Mädler	9·6	24·6	In	+15·1 !	1·29	In	−0·21
53·14	Jacob	6	10·5	2n	+1·2	1·50	2n	+0·01
54·67	Mädler	9·6	21·2	2n	+12·2 !	1·30	2n	−0·15
56·28	Jacob	6	7·6	2n	−0·9	1·44	In	+0·02
58·09	,,		8·3	2n	+0·2	1·56	2n	+0·19
58·21	Mädler	9·6	21·7	In	+13·6 !	1·31	In	−0·06
59·15	Dawes	8½	10·6	In	+3·7	1·41	In	+0·06
62·22	Mädler	9·6	24·5	In	+17·6 !	1·30	In	+0·03
62·95	Dembowski	7	7·5	5n	+0·9	1·13	4n	−0·11
68·13	Peirce	15	5·0	In	+0·4	0·75	In	−0·32
72·99	Brünnow	11¾	1·9	In	0·0	1·52	In	+0·65
74·07	Wilson	8¼	14·9	3n	+13·9	1·29	3n	+0·47
78·51	Burnham	18½	7·4	2n	+11·1	0·58	2n	0·00
90·88	,,	36	single			0·18		
91·73	,,	36	,,			0·17		
99·71	Aitken	36	,,			0·41		
1900·78	Burnham	36	no certain elongation			0·44	} computed	
2·74	,,	36	,,		,,	0·48		
4·69	Hussey	36	single			0·53		

Measures and Residuals, Observed – Computed—continued.

Date.	Obs.	Apert.	Pos.-Ang. 1925.		Res.	Dist.		Res.
		″	°		°	″		″
1906·21	Aitken	36	37·9	4n	−1·2	0·53	4n	−0·05
8·22	,,	36	37·4	3n	+0·8	0·63	3n	−0·02
8·42	v. Biesbr.	15	35·8	3n	−0·3	0·62	3n	−0·04
8·77	Burnham	40	39·0	2n	+3·3	0·69	2n	+0·02
10·80	Doolittle	18	32·6	2n	−0·9	0·56	2n	−0·19
12·93	v. Biesbr.	15	32·2	1n	+0·5	0·69	1n	−0·13
13·18	Aitken	36	29·6	1n	−1·8	0·81	1n	−0·02
14·74	,,	36	32·8	3n	+2·5	0·94	3n	+0·06
17·08	,,	36	29·3	1n	+0·4	0·88	1n	−0·07
21·10	v. d. Bos	10½	26·8	4n	−0·2	0·98	4n	−0·09

Ephemeris.

	°	″
1925·30	25·1	1·18
30·30	23·7	1·29
35·30	22·0	1·40
40·30	20·7	1·49
45·30	19·7	1·57

At the first glance the orbit seems to give the distances too large after 1906, but, bearing in mind that van Biesbroeck's and my own distances are generally measured too small, and that Aitken's measure in 1914 (mean of three nights) gives a positive residual quite as large as his most negative, the effect disappears.

Adopting the parallax 0″·027, as given by Hertzsprung (*A.N.*, No. 5000), I find for the sum of the masses 2·57 times the mass of the sun.

Computing the relative radial velocity of the two companions, I find a maximum value of 22 km. per sec. for 1889, while in 1922 the two radial velocities are equal. If the radial velocity of the primary had been measured in 1889, then we would have had the mass ratio simply by remeasuring this quantity now.

I make this remark because there are several binaries in similar circumstances; if the companion is approaching the primary with increasing speed nearly in a straight line, the inclination or the excentricity or both will probably have a large value, and then measures of radial velocity may be promising.

I am at present measuring the difference of declination between 80 and 81 Tauri on photographic plates, with the purpose of determining the mass ratio; but the radial velocity would have been a splendid test.

I am greatly indebted to Professor Aitken for sending the measures for 1910, 1913, and 1914, and to Professor Hertzsprung for valuable advice and for his interest in the work.

Leiden Observatory:
1921 *April* 29.

Observations of Comets a 1921 (*Reid*) *and b* 1921 (*Pons-Winnecke*), *made at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

The following observations were made by Mr. Crommelin with the Sheepshanks Equatorial (aperture 6·7 inches) by taking transits over two cross-wires at right angles to each other, each inclined 45° to the parallel of declination. Magnifying power 55.

G.M.T. 1921.	Comet − ✳ . R.A.	Comet − ✳ . Decl.	Log Factors of Parallax.	No. of Comps.	Apparent Place of Comet. R.A.	Apparent Place of Comet. Decl.	Comp. Star.
			Reid's Comet (*Obsr. A.C.*).				
d h m s	m s	′ ″			h m s	° ′ ″	
Apr. 27 10 38 27·46	−1 28·49	− 4 23·5	9·7079 *n*	0·8023	4	20 52 16·56	+50 41 44·2	*a*
,, ,, 10 47 21·34	+5 8·17	+13 42·8	9·7165 *n*	0·7922	1	20 52 15·30	+50 42 55·0	*b*
,, 28 8 49 54·03	+1 50·81	+ 7 18·3	9·5534 *n*	0·8849	4	20 55 6·34	+54 0 59·8	*c*
,, ,, 8 54 11·86	+2 24·30	− 9 55·4	9·5649 *n*	0·8821	2	20 55 9·92	+54 1 47·7	*d*
,, 29 9 2 29·56	+3 23·01	− 2 22·9	9·6267 *n*	0·5109	1	20 58 51·39	+57 38 57·6	*e*
,, ,, 9 2 29·56	−1 54·46	+ 1 28·2	9·6267 *n*	0·5109	1	20 58 50·31	+57 38 56·7	*f*
May 9 9 10 30·78	+0 44·52	+ 0 25·8	0·3955	0·7132	2	2 28 35·29	+85 27 56·1	*g*
			Pons-Winnecke Comet (*Obsr. A.C.*).				
Apr. 27 9 58 8·70	−0 37·08	+ 0 20·9	9·6530 *n*	0·5382	8	16 37 50·07	+42 37 3·7	*h*
,, 28 9 8 19·54	−0 38·47	+ 5 13·7	9·6878 *n*	0·6347	2	16 40 56·82	+42 55 52·9	*j*
,, ,, 9 30 17·85	+0 4·48	− 7 19·6	9·6760 *n*	0·5824	5	16 41 2·60	+42 56 13·6	*k*
May 8 10 3 39·27	+0 2·99	+ 3 1·9	9·6688 *n*	0·4795	4	17 20 14·60	+45 34 56·6	*l*
,, ,, 10 15 58·40	−0 34·47	− 4 48·9	9·6560 *n*	0·4510	3	17 20 18·05	+45 35 7·0	*n*
,, ,, 10 18 15·36	+0 15·03	+ 0 34·5	9·6535 *n*	0·4462	7	17 20 17·77	+45 35 2·8	*m*
,, 9 9 49 34·17	−0 10·78	− 4 47·0	9·6835 *n*	0·5084	1	17 24 57·27	+45 46 10·1	*p*
,, ,, 9 51 34·02	+2 27·72	− 1 10·5	9·6818 *n*	0·5049	2	17 24 55·41	+45 45 54·8	*o*

Comparison Stars.

	Name.	Mag.	Mean Position 1921·0. R.A.	Mean Position 1921·0. Decl.	Reduction to App. Place. s	Reduction to App. Place. ″	Authority.
			h m s	° ′ ″	s	″	
a	Piazzi 20h 412	5·8	20 53 43·876	+50 46 14·64	+1·175	−6·97	A.G. Cat., Harvard.
b	B.D.+50° 3209	7·7	20 47 5·924	+50 29 19·20	+1·207	−7·00	,, ,,
c	B.D.+53° 2519	9·5	20 53 14·330	+53 53 48·72	+1·198	−7·25	Greenwich photograph.
d	B.D.+53° 2517	9·0	20 52 44·427	+54 11 50·32	+1·198	−7·28	A.G. Cat., Harvard.
e	B.D.+57° 2268	8·0	20 55 27·175	+57 41 28·02	+1·208	−7·54	,, Helsingfors.
f	B.D.+57° 2275	8·5	21 0 43·584	+57 37 35·96	+1·181	−7·49	,, ,,
g	Lal. F. 374	8·6	2 27 54·893	+85 27 32·80	−4·120	−2·51	Greenwich 1900 and Greenwich Astro. Cat.
h	B.D.+42° 2736	7·5	16 38 24·929	+42 36 49·73	+2·226	−6·97	Monnichmeyer Cat., Bonn.
j	B.D.+42° 2743	8·5	16 41 33·052	+42 50 45·96	+2·235	−6·73	A.G. Cat., Bonn.
k	Anonymous	9·5	16 40 55·88	+43 3 39·9	+2·237	−6·74	Greenwich photograph.
l	B.D.+45° 2527	9·3	17 20 9·246	+45 31 58·93	+2·366	−4·27	Bonn Obs., vol. vi.
m	B.D.+45° 2526	9·2	17 20 0·374	+45 34 32·57	+2·366	−4·28	,, ,, x.
n	B.D.+45° 2529	9·5	17 20 50·152	+45 40 0·22	+2·365	−4·29	Equat. Comp. with *m*.
o	B.D.+45° 2532	8·9	17 22 25·308	+45 47 9·32	+2·382	−4·03	A.G. Cat., Bonn.
p	B.D.+45° 2536	8·8	17 25 5·675	+45 51 1·55	+2·376	−4·04	,, ,,

Comet *b* was a difficult object to observe with the Sheepshanks Equatorial, being faint and ill-defined.

The observations are corrected for the effects of the motion of the comets, but not for parallax or differential refraction.

Meridian observations of Reid's comet *sub polo* were obtained with the transit-circle on two nights. (Parallax not applied.)

G.M.T.	App. R.A.	App. Decl.	Obs.
d h m s	h m s	° ′ ″	
May 8 9 24 33·42	0 29 11·11	+84 45 19·1	A.C.
,, 9 11 32 37·62	2 41 32·90	+85 27 45·82	H.A.

The following observations were obtained from photographs taken with the 30-inch reflector. No corrections for parallax have been applied. On each plate the position of the comet was determined from three or four reference stars whose places were taken from the A.G. Catalogues.

G.M.T. 1921.	Apparent Place of Comet. R.A.	Apparent Place of Comet. Decl.	Log Factors of Parallax.
	Pons-Winnecke Comet.		
d h m s	h m s	° ′ ″	
Apr. 12 9 52 20	15 57 59·75	+37 14 33·7	9·6384 *n* 0·6404
,, ,, 10 19 14	15 58 2·36	+37 15 2·2	9·6190 *n* 0·6057
,, ,, 12 7 56	15 58 12·15	+37 16 46·6	9·4421 *n* 0·4464
,, 14 10 25 20	16 2 39·17	+38 1 1·4	9·6126 *n* 0·5801
,, ,, 11 2 28	16 2 42·71	+38 1 35·8	9·5672 *n* 0·5238
May 8 12 31 40	17 20 42·15	+45 36 22·0	9·3606 *n* 0·1031
	Reid's Comet.		
Apr. 28 12 49 19	20 55 43·49	+54 37 10·5	9·7998 *n* 0·5555

Observations of the Solar Eclipse of 1921 *April* 7, *made at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

In view of the unsatisfactory observations of contact-times at previous solar eclipses, a trial was made of the method suggested by Mr. R. T. A. Innes of making observations of the distance between the cusps near the times of contact. The method of projection of the sun's image on a screen was employed, as this enabled two observers to work with each instrument, each of them marking the position of one of the cusps at regular time-intervals. The scale of the image was determined by marking the length of the sun's diameter in a direction parallel to the line of cusps; a small error in the assumed solar diameter would have an inappreciable effect on the cusp-distance. The method of reduction

is as follows:—Let A, B be the cusps (diagram unnecessary), C the middle point of AB, *m*SCM*s* the common diameter of moon and sun, S, M being the ends of the diameters nearest to the line AB. Then $AC.CB = mC.CM = SC.Cs$, or $CM = \frac{1}{4}(AB)^2/mC$, $SC = \frac{1}{4}(AB)^2/Cs$, all distances being expressed in seconds of arc. *Cs*, *m*C can be first taken equal to the diameters of sun and moon (augmented), and then corrected when CM, SC are known approximately.

The change of apparent distance of centres of sun and moon in a second was then calculated for each contact and found to be $''\cdot451$, $''\cdot384$ respectively. The division of the length SC + CM by these quantities gives the time-interval between the observation and the contact. Photographs taken by Mr. Newton near the contacts were reduced in a similar manner.

The following are the separate results:—

Instrument.	Observer.	G.M.T. First Contact.	No. of Comp.	G.M.T. Last Contact.	No. of Comp.
		h m s		h m s	
Photo-heliograph	N.	19 34 54·88	2	22 4 59·22	2
Astrographic Eq.	H.J. & P.M.	57·18	1	61·25	10
Sheepshanks ,,	A.C. & R.C.	58·78	7	59·32	7
28-inch ,,	W. & H.A.	...	...	60·98	21
Adopted times		19 34 57·11		22 5 0·19	

C.D. made a direct observation of last contact $22^h\ 4^m\ 58^s\cdot08$. A preliminary computation had been made of the contact-times, using the corrections to the Moon's *N.A.* co-ordinates $+^s\cdot77$ R.A., $+4''\cdot9$ Decl. The resulting times were respectively $3^s\cdot78$ and $1^s\cdot79$ later than the above observed times, indicating the necessity of increasing the R.A. correction.

Four photographs were taken near the time of maximum phase. The following table shows the deduced position angle of the moon's centre from the sun's centre for each photograph, and comparison with a computation in which corrections of $+^s\cdot87$, $+4''\cdot9$ were applied to the *N.A.* co-ordinates.

G.M.T.	Position Angle. Computed.	Position Angle. Measured.	Computed Distance between Centres.
h m s	° ′	° ′	″
20 44 1·9	318 20·4	318 20	216·2
46 1·9	331 45·6	331 49	205·9
48 1·9	345 41·4	345 43·5	207·15
50 1·9	358 40·3	358 47	220·25

After applying corrections for differential refraction and additional corrections of $+^s\cdot015$, $-''\cdot15$ to the tabular R.A. and Decl. the errors of the tabular position angles become $+1'\cdot2$, $-1'\cdot2$, $+2'\cdot0$, $-1'\cdot6$.

Hence the correction to the tabular place of the moon, relatively to that of the sun, resulting from all the observations of the eclipse is $+^{s}\cdot88$, $+4''\cdot75$.

The *N.A.* place referred to is that in the Moon's Hourly Ephemeris, p. 43. In the Eclipse Elements on p. 419 corrections of $+^{s}\cdot40$, $+4''\cdot4$ are applied to the p. 43 values, although no indication of the change is given in the Almanac. It should be stated that in the computation made at Greenwich the values of the semi-diameters and parallaxes used were deduced from the eclipse elements on p. 419.

In the deduction of position angle of moon's centre from sun's centre from the mid-eclipse photographs no assumption was made as to the photographic semi-diameter of either body. Each limb was simply assumed to be a circular arc, and its centre was deduced geometrically.

Measures made on the plates of the width of the bright crescent at its middle point afford a test of the photographic semi-diameters.

The excess of the observed width of crescent over that computed is $5''\cdot77$, $1''\cdot85$, $2''\cdot57$, $2''\cdot95$, giving a mean of $3''\cdot29$. If the tabular semi-diameters are correct the excess may be ascribed to photographic irradiation, which in this case would amount to $1''\cdot64$ at each limb.

Attempt to Photograph the Spectrum of the Lower Chromosphere during the Partial Solar Eclipse, 1921 *April* 7–8. By H. F. Newall, F.R.S.

The successful attempts made by Professor Fowler (*M.N.*, **72**, 538) and by myself (*M.N.*, **72**, 536) to observe the "Flash" spectrum of the lower chromosphere during the partial eclipse of the sun in 1912 April 17 showed that good results could be obtained both visually and photographically during a partial eclipse of considerable magnitude.

Accordingly preparations were made to repeat the experiment more carefully during the partial eclipse of 1921 April 7–8. Photographs were obtained of the spectrum of the sun's limb close to the tip of the crescent with the McClean solar instruments at the Solar Physics Observatory, Cambridge. These instruments give an image of the sun 168 mm. in diameter, thrown on the slit of an autocollimating spectrograph with a camera 14 feet long and a 6-inch Michelson grating. The photographs were taken in the spectrum of the first order, giving a linear dispersion of 1 mm. to 4·02 tenth-metres in the spectral region chosen, viz. 4050 to 4420. The length of the slit exposed to the light of the chromosphere was 10 mm., and the spectrum was consequently 10 mm. high along the Fraunhofer lines. The width of the slit was 0·042 mm. The slit was inclined at 10° to the tangent to the sun's limb, and in this way it was hoped to get good data for

the measurement of the extension beyond the sun's limb of the chromospheric lines of various elements, which in the spectral region chosen are known to show a great variety of extensions.

The observing conditions were as favourable as could be wished, and the programme of observations was carried out completely successfully. Two plates were exposed on the west limb at position angles 270° and 290° just before and just after the epoch of greatest phase, with the slit inclined at 10° to the tangent, and a third plate was exposed on the east limb immediately afterwards with the slit tangential to the sun's limb. Each of these photographs shows good contrast between the parts exposed to the crescent and the parts exposed to the chromosphere outside the limb and the superimposed light of the sky.

But only the hydrogen lines H_γ and H_δ appear as bright lines, and not a single bright metallic chromospheric line can be detected on the plates. Thus the experiment has been a disappointing failure.

It was thought that the failure might possibly be referred to the brightness of the light scattered in the earth's atmosphere. But calculation of the areas of the uneclipsed portions of the sun's disc shows that there is no great difference between the eclipses of 1912 and 1921. The area of the uneclipsed portion of the sun's disc at greatest phase was calculated in terms of the area of the whole disc:

$$\frac{R^2\left(\frac{\pi}{2}+\alpha+\cos\alpha\sin\alpha\right)-r^2\left(\frac{\pi}{2}\pm\beta\pm\cos\beta\sin\beta\right)}{\pi R^2},$$

where R and r are the radii of sun and moon, and $\frac{\pi}{2}+\alpha$, $\frac{\pi}{2}\pm\beta$ are the semi-angles of the sectors involved in computing the segments of the sun and moon upon the common chord at greatest phase. The results are as follows:—

	Magnitude of the Eclipse (Sun's Diameter = 1).	r/R.	Area of Uneclipsed Portion in Terms of Area of whole Disc.
1912	·906	1	0·119
1921	·89	0·973	0·150

It seems improbable that a change from 12 per cent. to 15 per cent. should be of decisive importance in the observation. And yet the chromospheric lines appeared in 1912 with exposures of 10 and 20 seconds, and fail to appear in 1921, even with the considerably longer exposure of 65 seconds.

The bright hydrogen lines are seen to extend to the extreme limit of the spectrum. The relation which gives the radial extension h from the sun's limb corresponding to any point on the slit is

$$h = l\,\frac{\cos\phi-\cos(\theta+\phi)}{\sin\theta},$$

where l is the distance measured along the slit from the point of the slit where the sun's limb crosses the slit, and ϕ is the angle which the slit makes with the tangent to the sun's limb (10° in this case) and θ is the angle at the centre of the sun's disc.

Comparisons with spectro-heliograms secured by Mr. Butler during the eclipse show that in the two western photographs the slit happened to cross two fine prominences which sprang from the limb at solar latitudes +23° to +25° N.W. and +35° to +47° N.W. respectively. In the photograph exposed at position angle 290°, the widths of the hydrogen lines H_γ and H_δ have been measured at various distances from the sun's limb, with the following results:—

Distance from Sun's Limb.	Width of H_δ in tenth-metres.	Width of H_γ in tenth-metres.
	λ	λ
− 3″·8 (inside)	0·39 Dark reversal	0·38 Dark reversal
− 2·0 ,,	0·32 ,,	0·35 ,,
− 2·0 ,,	...	1·15 Bright line
0·0 (on limb)	0·89 Bright line	1·05 ,,
+ 3·5 (outside)	0·80 ,,	0·63 ,,
+ 5·0 ,,	0·61 ,,	0·72 ,,
+ 7·5 ,,	0·58 ,,	0·85 ,,
+10·0 ,,	0·49 ,,	0·56 ,,
+14·5 ,,	0·45 ,,	0·34 ,,
+17·5 ,,	...	0·38 ,,

By reason of the movement of the moon during the exposures, the higher parts of the chromosphere received longer exposures than the lower parts, the actual times having been 75 seconds, gradually decreasing to 10 seconds at position angle 270°, and 75 seconds gradually decreasing to 20 seconds at position angle 290°. It was anticipated that this condition would help to accentuate the measurable extensions of the different elements, if the chromospheric lines impressed themselves on the plate. In the western photographs the lowest chromosphere received exposures of 10 and 20 seconds respectively. In the photograph taken on the eastern limb the exposure for the lowest chromosphere was 65 seconds, but no corresponding bright lines appear on any of the plates except H_γ and H_δ.

Mr. Milne secured a photograph of the spectrum of the sun's western limb at position angle 270° with the spectrograph attached to the Huggins refractor. It exhibits only the bright hydrogen lines H_β to H_ζ and the two calcium lines H and K, all of them beautiful narrow lines showing some distortions attributable to velocity in the line of sight, but no bright metallic chromospheric lines are detectable. The sun's image with the Huggins refractor has a diameter of only 40 mm., compared with the 168 mm. image

with the McClean instruments, and the observations were correspondingly more difficult and the results none the less disappointing.

Two other photographs were taken with the McClean instruments with the slit exposed close to the limb of the moon, and just *within* the limb of the moon and parallel to the tangent. One of these, taken on the western side, exhibits simply the Fraunhofer spectrum with inequalities of intensity extending right along the spectrum, an effect which may safely be ascribed as due to the inequalities (mountains and valleys) at the moon's limb, which are responsible under suitable conditions for the phenomena of Baily's Beads. The second photograph, taken at the eastern limb, exhibits the Fraunhofer lines again, but in this case the hydrogen lines H_γ and H_δ are reversed bright.

These photographs were taken with a view of seeing whether there are any indications of an atmosphere of the moon of such a nature as to give absorption lines in the spectral region photographed. According to the views of Julius in regard to anomalous refraction, such lines might be expected to be reversed (bright) in the conditions of the observation. But no signs of bright reversals are visible with the exception of the hydrogen lines; and their bright reversal is an effect more probably due to the telluric scattering of the light of luminous hydrogen in a large flocculus known to have been close to the moon's limb than to the existence of an atmosphere of hydrogen round the moon.

Solar Physics Observatory, Cambridge:
1921 *May* 11.

The Partial Eclipse of the Sun, 1921 *April* 7: *Spectroscopic Observations of the Reversing Layer.* By the Rev. A. L. Cortie, S.J., and the Rev. J. Rowland, S.J.

About mid-eclipse, from 20.30 to 21.10 G.M.T., the spectrum at the northern cusp was observed with the Browning 12-prism spectroscope, a dispersion of 8 prisms of 60° being employed. The slit was kept in a radial position at the tip of the advancing cusp. The position of the spectrum observed was from the *b* group, λ5167, to λ5400, so as to include the coronal line λ5303. Every line in the field was reversed, the bright lines tapering to a point, indicating decrease of pressure. The lines were of different lengths, the longest lines being the Mg lines of the *b* group, and a line near E, probably the Ca line λ5266. When the cusps became blunted the field contained both bright and dark lines. With a correct position of the slit the lines could be held in the field of view for comparatively long intervals, in spite of the clock working badly, and a consequent frequent moving of the telescope with the slow-motion rod.

Unfortunately the main building of the observatory blocked the sun from the heliostat mirror which supplies the spectrograph with light, consequently the instrument could not be employed. But from the length of time during which the bright lines were seen, even under adverse circumstances, there would have been no difficulty in photographing the flash spectrum in all its phases. A right-angled prism had been mounted, which, by a slight rotation, would have enabled the tip of the cusps to have been maintained in a suitable position on the vertical slit of the instrument. The experience at this eclipse conforms entirely with that of Professor Fowler, as described by him in his extended account of his spectroscopic observations of the partial eclipse of the sun, 1912 April 17.*

The coronal radiation at λ5303 was not detected. It may have been present, but masked by the great brilliancy of the chromospheric lines in the field of view.

Eclipse of Rhea by the Shadow of Titan. By L. J. Comrie, M.A., and Major A. E. Levin.

Observations of the eclipse of one satellite by the shadow of another are very rare. Webb † states that there is only one recorded instance of an eclipse of one of Jupiter's satellites by the shadow of another, but does not give a reference. An observation is reported in *B.A.A. Journal* ‡ which was, in all probability, a partial eclipse of II. by the shadow of III. Nevertheless there are frequent reports of mutual occultations, and as a mutual eclipse seen from the earth would appear to an observer on the sun as a mutual occultation, it is certain that many more have passed unobserved, probably because of the absence of predictions. A carefully recorded observation would be valuable, as the observation is easy to make, and it affords a much more sensitive check on the tables than does an eclipse by the shadow of the primary.

An eclipse of Rhea by the shadow of Titan was predicted in *B.A.A. Journal*, 31, 161, by the authors. The prediction was based on Struve's elements for the satellites concerned, together with data in the *Berliner Jahrbuch*. The periodic solar perturbations of Titan were not taken into account. The diameter of Titan as seen from the sun was taken as $0''\cdot6$, that of Rhea as $0''\cdot3$, while the diameter of the shadow through which Rhea passed was found to be $0''\cdot5$, and the separation of the satellite centres at heliocentric conjunction $0''\cdot12$. The deduced time of mid-eclipse was 1921 April $8^d\ 10^h\ 38^m$, and the duration 44^m.

* *Monthly Notices*, 72, 538.
† *Celestial Objects for Common Telescopes*, 1, 196 (6th edition).
‡ 6, 365.

With the consent of the parties concerned the following observations are put on record :—

(1) P. H. Hepburn and A. E. Levin, observing together with 12-inch reflector at Hampstead, and using powers 160 and 310. Both immersion and emersion were well observed, and by pairing estimates of brightness at both phases the deduced time of mid-eclipse is $10^h\ 47^m{\cdot}4 \pm 0^m{\cdot}5$, the latter figure being an empirical estimate of the uncertainty of the mean time. Rhea was completely invisible for over half an hour.

(2) L. J. Comrie, observing with 12-inch Sheepshanks equatorial refractor at Cambridge, using 200. The times and notes were recorded by Mr. R. G. Ridling. Both phases were observed, the concluded time of mid-eclipse being $10^h\ 47^m \pm 1^m$. Rhea was invisible for 38^m.

(3) E. A. L. Attkins, using 8½-inch reflector at Squirrel's Heath, with power 350 and power 525, obtained good observations of the immersion, but failed to see the emersion because of clouds.

(4) F. Burnerd, with 8½-inch reflector at Putney, secured observations through breaks in clouds.

(5) C. J. Spencer, with 4½-inch refractor, observed both phases from Halifax. His observation of immersion is earlier and his emersion later than those of other observers, probably because of the smaller aperture used.

The last three observations, although only partial, have been particularly useful in determining when the fading of Rhea was first detected. From all the records the time of mid-eclipse seems to be $10^h\ 47^m{\cdot}3 \pm 0^m{\cdot}5$, and the detected duration at least 50^m, *i.e.* from $10^h\ 22^m$ to $11^h\ 12^m$. Both the disappearance and reappearance were fairly sudden, for Rhea was invisible in the 12-inch telescopes used by (1) and (2) for more than two-thirds of the total duration of the eclipse.

These records should afford a good check on the tables used for Rhea and Titan. The observation is subject to a greater nicety than is an observation of an eclipse by the shadow of Saturn; further, this eclipse would be affected by an error, say in the longitude of Titan, to an extent three times greater than would an eclipse of Titan by Saturn. The duration, combined with the known relative movement, gives us immediately a lower limit for the sum of the diameters of Rhea and Titan. If we accept Barnard's micrometrical measure of Titan it seems, provisionally, that the diameter of Rhea is nearer $0''{\cdot}4$ than the value $0''{\cdot}3$ assumed. This discussion of the observations is intended to be preliminary only, and will be renewed when the observations of satellite phenomena for this opposition and that of next year are all to hand.

Erratum.

P. 454 (date of letter), *for* December 16 *read* December 30.